Osmundaceæ have recently acquired a remarkable interest from the researches of Kidston and Gwynne-Vaughan, who have succeeded in tracing back this family, on anatomical evidence, to a common origin with the Palæozoic Botryopterideæ. The adder's tongues, on the other hand, have been separated from the ferns by some authorities. The author lays stress on the relations of this family to the Sphenophyllum-Psilotum type, as well as to the ferns and Cycadofilices.

Lecture ix. is occupied partly with the filicinean leaf-trace, partly with the development of the vascular system in the individual plant (ontogeny). In introducing the latter subject an interesting comparison is drawn between animal and vegetable embryology (p. 121).

In the final lecture the vascular system of the ferns is compared with that of other phyla of vascular plants. A valuable criticism of Prof. Jeffrey's proposed division of the higher plants into Lycopsida and Pteropsida is given in this connection. Sections on the morphological construction of Selaginella compared with that of the ferns (with which a remarkable analogy is ingeniously traced), and on the relations of ferns and seed-plants, conclude the course.

The book is an admirable example of the evolutionary treatment of the anatomical structure of plants, a line of research in which English-speaking botanists have for some time past taken the lead, the author himself being one of its best exponents.

We have only one verbal criticism to add; it is a pity that the author lends his sanction to the misuse of the word *hypothecate*, now becoming frequent among certain of the younger writers of scientific papers. He speaks of "such an ancestor as we have hypothecated" (p. 6). We have learnt from Sir W. S. Gilbert that ancestors may be bought, but it was reserved for the modern botanical author to discover that they may be *mortgaged*!

A glossary, bibliography, and index complete the volume.

D. H. S.

ELECTRICAL ENGINEERING.

Heavy Electrical Engineering. By H. M. Hobart. Pp. xxiv+338. (London: A. Constable and Co., Ltd., 1908.) Price 16*s*. net.

WITH so prolific an author as Mr. Hobart, the expectation of finding in any new book a good deal of old matter in a new guise is but natural, but in the present case such an expectation would be quite erroneous. This book is original from beginning to end; moreover, it is a perfect store of useful practical data and is clearly written, so that the reader always remains in touch with the author and knows what point he wishes to make. These points are not matters of little detail, but the features in a design which really count. It is this ability of Mr. Hobart to take a broad and comprehensive view of his subject which makes this book so eminently readable. But in parts it is also highly controversial, and although also these parts are interesting reading, one cannot help feeling a little anxious for the author lest he should prove a false prophet. Thus he calls the London, Brighton and South Coast electrification "this single-phase monstrosity," and devotes several pages to prove that the work could have been done for two-thirds the money on the direct-current system and in much less time. It may be that he is right, but if one remembers that the Swiss railway committee, which has been deliberating for three years, has not yet taken heart to condemn the single-phase system root and branch as Mr. Hobart does, a saying about a region where angels fear to tread comes to one's mind. Another point on which the author is equally dictatorial in his judgment concerns the transmission of power by high-pressure continuous current on the series system.

The general scope of the work is excellent. The author takes in succession all the parts of a large electricity supply undertaking, and shows us the determining factors and their relative importance in the right perspective. The metric system is used throughout, and as unit of power the kilowatt. As unit of energy the author uses the kilowatt-hour, whether the energy be mechanical or heat. Thus we find even such quantities as the specific heat and the latent heat of steam expressed, not in calories, but in kilowatt-hours. As the unit mass to which these quantities are referred he takes one metric ton of steam or water. In the first two introductory chapters are given tables on the property of steam in the new measure, evaporative power, cost and calorific value of coal, the over-all efficiency of generating stations, an analysis of the losses, the plant capacity in various stations, the demand for light, power, and traction in various towns, &c., all from actual experience and carefully tabulated. He then shows by way of example how the figures collected may be used to design an electricity works for a town of one million inhabitants, and comes to the conclusion that the immediate demand would be for 77 million kilowatt-hours per annum, and the demand in the course of the next ten years 120 million kilowatt-hours. The works should, therefore, be designed with the view of an extension up to this limit. With chapter iii. and subsequent chapters we enter into the more technical part of the subject, namely, steam-raising plant, engines and turbines, generating machinery, condensing plant, and the generating station considered as a whole. This brings us to chapter viii., which deals with overhead lines and underground cables, whilst the last two chapters are devoted to a criticism of the Thury system and to electric traction.

Most of what the author has to say on steam engines is concerned with turbines, and very little is said about piston engines. Neither does the author discuss the advantage of combining the piston engine with the turbine in the sense that the former utilises the high-pressure steam and exhausts into the latter. His ideas as to the ultimate size of turbine sets are on a grand scale. He thinks that units of 10,000 to 20,000 kw. at pressures up to 20,000 volts will come into use. Curiously enough, he says nothing about the question of how sets of this magnitude are to be kept cool. It

is quite obvious that the air required for ventilation would not only have to be supplied in huge quantities by special fans, but also that it would have to be carried away in closed ducts to the outside of the engine-room.

When dealing with gas engines for alternating-current generators the author falls into a strange error. He mentions as one of the drawbacks that power is lost through the damping coils which the irregular motion of a gas engine renders necessary. Now it is well known that damping coils must not be used in such cases. His remarks on slot insulation, on which subject he is an authority, are highly interesting; he believes that eventually it will be possible to reduce this to something like 2 mm. for a 10,000-volt machine, but unfortunately he does not say in what manner this improvement is to be achieved. He is evidently an advocate of severe testing, and the subject of insulation tests gives him the opportunity of a homily on the ethics of the inspecting engineer. His suggestion that the sufficiency of the mechanical support of the winding should be tested by short-circuiting at full excitation the terminals of, say, a 5000-kw. alternator sounds rather heroic, and his anticipation that not more than six times normal current would flow at the instant of closing the switch may be doubted, although he is quite right in saying that, a moment after, the current would only be about three times the normal value.

The chapter on the design of the central station as a whole is particularly interesting and useful. Here we find an enormous mass of information collected from a variety of stations and tabulated in a convenient form. The same may be said of the chapter on transmission plant. The author gives us, not only technical details, but also the cost from actual experience, and one cannot but admire the industry with which he has collected so much really valuable information. As regards electric traction, his sympathies are all for the direct-current system, for which he predicts a rise of working pressure up to something like 1200 volts. The single-phase system he condemns entirely, but as regards the three-phase he admits a slight superiority in the matter of weight over the direct-current system. As the limits of the power of motors at the ordinary one-hour rating he takes 150 h.p. for the single-phase, 300 h.p. for the continuous, and 400 h.p. for the three-phase system. The three-phase system is a little lighter, and the single-phase system more than twice as heavy as the continuous-current system. A new and very simple formula for the tractive resistance in kg. per ton of train is given on p. 231. It is as follows:—

$$R = 2\cdot70 + 0\cdot09 \frac{V^2}{W}$$

for railways in the open, and

$$R = 3 + 0\cdot3 \frac{V^2}{W}$$

for tube railways. V is the speed in km. per hour, and W is the weight of the train in tons.

GISBERT KAPP.

WHY LEAVES ARE GREEN.

Zur Biologie des Chlorophylls, Laubfarbe und Himmelslicht, Vergilbung und Etiolement. By Ernst *Stahl.* Pp. v+153. (Jena: Gustav Fischer, 1909.) Price 4 marks.

IN this interesting and suggestive book, Prof. Stahl presents us with the results of his observations and speculations upon the ever-interesting problems of the biology of chlorophyll and its related colouring matters. One of the most interesting of these is the cause of the prevailing green colour of our vegetation. How does it arise that the various photosynthetic organs of plants are green, and not some other colour?

Engelmann has already shown that the colours of the algal vegetation of the sea are complementary to the light which falls upon them, and Gaidukov has made experiments to show that the Cyanophyceæ, or blue-green algæ, undergo a change in colour complementary to the light which falls upon them, when grown under different coloured lights. Prof. Stahl thinks that these observations may lead to an explanation of the green colour of land plants. The chlorophyll spectrum may be regarded as a combination of two absorption spectra. The absorption at the blue end of the spectrum agrees very nearly with that of etiolin and the colouring matter of yellow leaves, whilst the absorption in the red corresponds to that of the green colouring matter which is formed when etiolated plants are exposed to light, and disappears in the autumn, when the leaves again turn yellow. The yellow-green colour of the leaf may, therefore, be an adaptation to the prevailing colour of the diffuse light which falls upon it, the yellow being complementary to the blue of the heavens, and the green to the orange and red which mostly prevail when the sun is low.

The region of least absorption in the chlorophyll corresponds with that of maximum energy in the spectrum. The plant does not, therefore, depend for its assimilative work upon the rays of greatest energy. On the other hand, the possibility of using these rays is shown by the red algæ, which absorb the green as well as the blue, the maximum of their assimilative activity lying exactly in the green.

The author tries to show that the non-absorption of the green rays is not only due to the fact that the chlorophyll makes no use of those rays which usually reach it in a weakened form, but also to the fact that the absorption of these rays in direct sunlight would be dangerous to the plant, because of their great heating power. Under normal conditions an intense illumination is unnecessary. The amount of energy used up by the chlorophyll grain in carbohydrate assimilation is only a small part of the total energy it absorbs. In light of lower intensities, however, it is clear that the amount of energy absorbed by the plant becomes more nearly proportional to the amount used for assimilation, and thus a complementary colour adaptation to the light is understandable. In the red and brown seaweeds, the blue-green algæ, &c., the absorption of